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Pulverized Fault Rocks Along the Arima-Takatsuki Tectonic Line, Japan: Fault Structure, Damage Distribution and Textural Characteristics

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In recent years, ‘pulverized rocks’ have been studied and described on various active traces of the San Andreas Fault. These rocks appear to have been shattered in situ, have very fine grain size, but do not appear to have been subjected to significant shear strain. How these rocks were created is currently not fully understood. Recent theories include pulverized rock genesis by dynamic rupture propagation on bi-material interfaces in fault zones with different seismic velocities across the fault or the slip zone. In such cases, there is an incompatibility along the propagating rupture tip that can produce ‘wrinkle-like’ pulses and strong dynamic weakening. Rupture associated with wrinkle-like pulses may form asymmetric damage structures and shattered "pulverized rocks" on the high velocity side.

Here, we present data from an outcrop of potentially pulverized rock along a portion of the Arima-Takatsuki Tectonic Line (ATTL), which extends from Kyoto, through Awaji Island, to the Median Tectonic Line. The ATTL is a dextral strike slip fault with a total displacement of around 17km; the main shock of the 1995 magnitude 7.2 Kobe earthquake was located at the mid-point of the ATTL. At the Arima Hotspring outcrop, the ATTL juxtaposes granite to the south against rhyolite to the north. The majority of slip appears to be localized to a clay-rich gouge fault core 8-10cm in width, surrounded by a coarsening outwards fault breccia around 1-2 metres wide. Fault damage is highly asymmetric with respect to the slipping zone: a several hundred-metre wide pulverized damage zone in the granite to the south of the fault, and a small non-pulverized damage zone consisting of fault breccia around 1-2m in width in the rhyolites to the north. This is consistent with bimaterial interface models suggesting preferential damage should be located on the higher velocity side of a fault. The degree of pulverization in the granite decreases with perpendicular distance from the fault. The highly fractured pulverized fault-rocks appear to exhibit distinct textural characteristics. In thin section, grains appear to be highly comminuted but the original grain shapes and margins are still recognizable. Grain fragments show little to no rotation, and appear to show a general lack of in-situ shear. Consequently, at macroscale the rocks appear to preserve original granitic textures, despite being highly fractured and friable to the touch. However, cross-cutting relationships of some localized shear zones and breccias surrounding larger macrofractures within the granite damage zone as well as considerable veining suggest that later stage faulting and fluid flow may also have occurred. Fault rock textures appear to share many similarities with existing well-documented observations of pulverized granitic rocks, such as that along the San Andreas, Garlock, and San Jacinto faults in southern California. We believe these rocks may be consistent with damage associated with models that suggest pulverized rocks are generated by the dynamic reduction of normal stress during successive earthquake events.